

PRESENCE OF THE PARASITE *PHILONEMA ONCORHYNCHI*
IN SOCKEYE SALMON RETURNING TO
UPPER COOK INLET, ALASKA IN 1991

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INTRODUCTION

Scale pattern analysis (SPA) has been used since the 1960's and has proven useful for determining racial origins of salmon captured on the high seas and along the Pacific coast region (Anas 1964; Anas and Murai 1969; Henry 1961; Lechner 1969; Major et al. 1973; Mosher 1963; and Wright 1965). Since scales were routinely collected from commercial catches as well as spawning escapements to provide age composition data, time and cost for obtaining SPA samples was less than that needed for other techniques (e.g. x-ray fluorescence spectroscopy or protein electrophoresis) that would have required new sampling strategies. In 1976 the Alaska Department of Fish and Game (ADF&G) initiated stock identification research using SPA (Krasnowski and Bethe 1978) to separate sockeye salmon *Oncorhynchus nerka* in mixed stock fisheries of Upper Cook Inlet (UCI), Alaska (Figure 1). Unfortunately, SPA results have been inconsistent and disappointing. Model classification accuracy has been relatively poor, minor stocks contributions tend to be over estimated, and the statistical reliability is questionable (Waltemyer and Tarbox 1988; Waltemyer and Tarbox 1991). Therefore, development of better sockeye salmon stock discriminators is needed to make stock identification a useful management tool for UCI sockeye salmon.

During the past decade, stock identification investigations flourished again throughout the Pacific Northwest United States and Canada (Bilton and Messinger 1975; Conrad 1982; Cook 1982; Cross and Goshert 1988; Eggers 1989; Garner 1983; Geiger 1989; Jensen and Frank 1988; Jones and Thomason 1984; Marshall et al. 1982; McGregor 1985; Millar 1988; Sharr et al. 1984; and Wood et al. 1988). SPA seemed to be the most widely used technique followed by genetic characters, parasite occurrence, tagging, age class composition, and mass marking (Geiger and Wilbur 1990). Since scale characters alone have not provided the desired accuracy for identifying stocks in UCI, we decided to examine other techniques which alone, or in combination with SPA, might improve our stock discrimination abilities. Parasite occurrence was selected because it could be added to our existing SPA program with minimal cost. Moles et al. (*unpublished*) have demonstrated the utility of parasite occurrence in salmon stock separation studies in Southeast Alaska.

In 1990 a pilot study was conducted to determine if parasite occurrence differed among UCI sockeye salmon stocks. Fourteen subpopulations of sockeye salmon were examined for the occurrence of two protozoans the brain parasite *Myxobolus neurobius*, the cartilage parasite *Henneguya* sp., and the coelom nematode *Philonema oncorhynchi* (Tarbox et al. 1991). Both protozoan parasites were absent from all stocks examined, but nematodes were present and their occurrence appeared to differ among stocks.

Specific objectives of our study were to (1) resample representative UCI sockeye salmon stocks, (2) provide temporal samples from the major river systems, (3) determine the feasibility of sampling the commercial drift fishery, and (4) evaluate the sensitivity of stock composition estimates based on known parasite occurrence rates and model selection.

METHODS

Sockeye salmon from 12 spawning locations and one commercial catch period were sampled for occurrence of *Philonema oncorhynchi* (Table 1). A sample size goal of fifty fish was set for each in-river or stock specific location and sample date based on criteria of lot size (abundance of stock population) and prevalence of infection as described by Amos (1985). A sample size goal of 300 fish was set for a commercial mixed stock sample based on the preceding criteria and assuming a minimum prevalence of infection equal to 2% with two populations of fish found in the sample. Sockeye salmon were collected by a variety of methods including fish wheel, seine, gig, and gillnet. In the Kasilof, Kenai, and Susitna Rivers, several samples were taken to assess temporal variation. Visual examination of the body cavity and organs was used to assess occurrence. A written log was maintained for each location which included standard age-weight-length (AWL) information for each sockeye sampled as described in Waltemyer (1991). Percent infected was calculated by location and sample date.

A three-stock model (1) Susitna mainstem, (2) Yentna, and (3) "Other" (which included Kenai, Kasilof, and Crescent Rivers) was used in a simulation analysis to evaluate how well parasite occurrence rates might estimate stock proportions for UCI sockeye salmon. Model simulations were conducted using the computer program *STOCKID* version 1.0 written by Jeff Bromaghin (personal communication, Biometrician, Division of Commercial Fisheries, ADF&G, Anchorage). *STOCKID* is a program designed to obtain conditional maximum likelihood estimates (Rao 1973) of the stock contributions of a mixture based upon a conditional likelihood function. Under the assumption that a multinomial sample is drawn from the mixture, the likelihood function, L , of the observed data is given by:

$$L = K \prod_{i=1}^T \left[\sum_{j=1}^S \pi_i \theta_{ij} \right]^{y_i}, \quad (1)$$

where:

- K = constant
- S = the number of stocks thought to contribute to the mixture
- T = the number of unique types observed in the mixture sample, in our case $T=2$, with parasite (1) or without (2).
- y_i = the number of individuals observed in the mixture of type i , $i = 1, 2, \dots, T$
- θ_{ij} = the proportion of stock i consisting of individuals of type j , $i = 1, 2, \dots, S$, $j = 1, 2, \dots, T$,
- π_i = the proportion of the mixture composed of individuals from stock i , $i = 1, 2, \dots, S$.

The likelihood function involves the observed random variable y_i and the parameters π_i and θ_{ij} . The π_i are the parameters of interest while the θ_{ij} are estimated from stock specific

samples (Freund and Walpole 1987). The program *STOCKID* computes conditional maximum likelihood estimates of π_i based on equation 1. Since equation 1 can't be expressed in closed-form, estimates must be obtained through use of numerical maximization techniques. *STOCKID* used a modified implementation of the reduced gradient technique (Luenberger 1984). Mean parameter estimates could also be obtained, the result of bootstrap replicates of the model with multinomial samples.

A closed form of equation 1 exists to estimate stock contribution between two stock groupings using parasite occurrence rates only. The number of fish with parasites (X) found in a sample of N fish is a function of the proportion of each stock group present (π_i , $i = 1$ or 2) and the proportion infested with parasites (θ_i , $i = 1$ or 2) for that stock grouping. Using the terminology of equation 1 this can be stated as:

$$X = N(\theta_1\pi_1 + \theta_2\pi_2) \quad (2)$$

We also know that π_1 equals $1-\pi_2$ which can be substituted into equation 2 which can then be solved for the remaining unknown value of π_2 as:

$$\pi_2 = \frac{\frac{X}{N} - \theta_1}{\theta_2 - \theta_1} \quad (3)$$

After pooling Yentna and Susitna Rivers into a common Susitna drainage stock we needed to evaluate the sensitivity of our stock composition estimates to our choice of a "pooled estimate" of parasite occurrence, θ . The new parasite occurrence rate was calculated as the average of observed 1990 occurrence rates from the mainstem sample location on the Susitna (RM 80.0) and Yentna rivers (RM 5.0; Tarbox et al. 1991) weighted by abundance. A range of average infestation rates was prepared letting Yentna River sockeye salmon represent from 0.8 to 0.3 of the total Susitna drainage return. Weighted estimates of parasite occurrence ranged from 0.39 to 0.46 (Table 2).

A further evaluation focused on the consequences of incorrectly specifying the parasite occurrence rate for the Susitna drainage stock (Susitna and Yentna pooled) when trying to estimate stock contributions in UCI. Proportions of Susitna drainage versus "Other" stocks with near 100% parasite occurrence were estimated using samples from known mixtures with Susitna occurrence rates of 0.3, 0.4, and 0.5. For each scenario stock proportions were estimated when not correctly specifying the Susitna drainage parasite rate from 0.2 below to 0.2 above the actual. Parameters of the two-stock models in equation 3 were estimated in a Lotus spread sheet.

RESULTS

A total of 1,371 sockeye salmon were examined for the presence of *Philonema oncorhynchi* (Table 1). The parasite was found in 98.0% to 100.0% of sockeye salmon sampled from the Kasilof, Kenai, Crescent and Chilligan Rivers, was absent in samples from Fish Creek (Big Lake), and was found in few sockeye salmon (2.0%) examined from Bishop Creek (Daniels Lake). Multiple samples taken over time from the Kenai River showed no deviation in parasite occurrence of 100%. Parasite occurrence varied among sample locations within the Susitna River drainage. Occurrence was low in Lake Creek (Chelatna Lake; 10%) and high in mainstem Susitna (RM 80.0; weighted mean, 84.7%) and Yentna (RM 5.0; weighted mean, 74.3%) river samples. Within Susitna River samples taken over time, parasite occurrence appeared to be less variable in mainstem samples (range 77.1% -92.2%) than in Yentna River samples (range 58.5% - 92.3%). In a single sockeye salmon sample obtained from the commercial drift gillnet harvest on July 15, occurrence was 90.7%.

Simulations using a three-stock model, (1) Yentna, (2) mainstem Susitna, and (3) "Other" (stocks with occurrence near 100%: Kenai, Kasilof, Crescent), indicated that Yentna and mainstem Susitna stock contributions could not be reliably estimated using parasite occurrence. This occurred because we were using a three-stock model with only two types of individuals (those with or without parasites). Model convergence was a problem and no reliable estimates could be obtained. However, when these two stocks were combined into a single Susitna drainage stock in a two-stock model (Susitna versus "Other"), estimates of various stock proportions could be obtained and evaluated (Table 3 and Figure 2). Estimates were fairly accurate, with percent errors less than 11%, when the Susitna stock comprised 30% or less of the stock mixture. However, a two-stock model added the additional requirement of specifying a "pooled" Susitna drainage parasite occurrence rate. Fortunately estimates of Susitna stock contribution were not sensitive to the relative abundance of Yentna and mainstem Susitna sockeye salmon within the pooled Susitna stock, if the occurrence was accurately specified (Table 4). Using the range of Susitna occurrence rates estimated for various Yentna and Susitna relative abundances (Table 2) a two-stock model was used to estimate a mixture composed of 0.6 and 0.4 Susitna. Percent error was below 5%, if the parasite occurrence rate was accurately specified (Table 4). Thus the model could accurately estimate the stock proportions.

An alternative three-stock model using Susitna, Other A (stocks with high occurrence), and Other B (stocks with low occurrence: Big River, Bishop Creek, Fish Creek) was also evaluated. Problems of convergence and unreliability indicated that it would be difficult to distinguish between Susitna and Other B stocks.

Estimates of the proportion of Susitna drainage sockeye salmon in known UCI mixtures were affected when the parasite occurrence rate was not correctly specified (Tables 5-7, Figures 3-5). Differences between actual and estimated proportions increased as parasite occurrence in the Susitna stock increased from 0.3 to 0.5 (Table 8). The differences between the estimated and actual proportions in known mixtures ranged from 67% when

the actual occurrence of 0.5 was estimated to be 0.7 to -12% when the actual occurrence of 0.3 was estimated to be 0.2.

Based on the mixture sample taken from the commercial drift gillnet harvest on 15 July, a minimum of approximately 10% (no parasite present) of the fish harvested were bound for the "Northern District". Using the two-stock model and a range of weighted estimates of Susitna River parasite occurrence (74.3% to 84.7%), the estimated proportion of the commercial harvest bound for the "Northern District" would range from 37% to 62%.

DISCUSSION

Use of *Philonema oncorhynchi* occurrence as a marker to separate sockeye salmon stocks in UCI is promising. Since occurrence was about 100% in all major sockeye salmon systems within Central District and varied within Northern District systems, a sockeye salmon which was not infested would have a high probability of being from a Northern District stock. The percentage of sockeye salmon without this parasite in commercial harvest samples would provide a minimum estimate of the contribution of Northern District stocks to the harvest. Actual Northern District contribution, specifically that from the Susitna River system, would be difficult to determine because incident rates vary among sample locations within this river system. However, use of parasite incidence in conjunction with genetic discriminators is being explored as a technique to enhance current stock discrimination capabilities for UCI sockeye salmon (Tarbox 1993).

Presently, 600 sockeye salmon are sampled from each commercial fishing period and from each spawning escapement for the purposes of estimating age composition. While it is a relatively simple task to determine parasite occurrence, requiring only visual examination of the body cavity, the amount of time required to sample would require additional personnel. Also computer software must be developed which incorporates parasite and other discriminators for estimating stock contributions. It would be prudent to continue sampling spawning populations to determine the yearly variation or stability in parasite occurrence. In addition, combining these data with other discriminators may enhance the power of detecting differences in stock components and subsequently provide more precise estimates of stock composition.

LITERATURE CITED

- Amos, K.H., editor. 1985. General sampling procedures. Pages 3-4 in Procedures for the detection and identification of certain fish pathogens, Third Edition. American Fisheries Society, Washington, D.C.
- Anas, R.E. 1964. Sockeye salmon scale studies. Pages 158-162 in International North Pacific Fisheries Commission Annual Report 1963.
- Anas, R.E., and S. Murai. 1969. Use of scale characters and a discriminant function for classifying sockeye (*Oncorhynchus nerka*) by continent of origin. International North Pacific Fisheries Commission, Bulletin 26: 157-192.
- Bilton, H.T., and H.B. Messinger. 1975. Identification of major British Columbia and Alaska runs of age 1.2 and 1.3 sockeye from their scale characters. International North Pacific Fisheries Commission, Bulletin 32: 109-129.
- Conrad, R.H. 1982. Separation of the 1981 Chignik sockeye salmon stocks by scale patterns and a linear discriminant function. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 76. Juneau.
- Cook, R.C. 1982. Stock identification of sockeye salmon (*Oncorhynchus nerka*) with scale pattern recognition. Canadian Journal of Fisheries and Aquatic Science 39: 611-617.
- Cross, B., and W.E. Goshert. 1988. Origins of sockeye salmon in the fisheries of Upper Cook Inlet in 1985 based on analysis of scale patterns. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 181. Juneau.
- Eggers, D.M. 1989. An overview of the application of stock identification methods in the management of Alaskan salmon fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 5J89-08. Juneau.
- Freund, J.E. and R.E. Walpole. 1987. Mathematical Statistics, 2nd edition. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
- Garner, L.A. 1983. An analysis of stock separation in the pink shrimp, *Pandalus borealis*. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 214. Juneau.
- Geiger, H.J. 1989. A stock identification study in the northern Alaska Peninsula sockeye salmon fishery, from Harbor Point to Stroganoff Point. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 5J89-11. Juneau.

LITERATURE CITED (Continued)

- Geiger, H.J., and R.W. Wilbur, editors. 1990. Proceedings of the 1990 Alaska stock separation workshop. Alaska Department of Fish and Game, Division of Commercial Fisheries, Special Fisheries Report 2. Juneau.
- Henry, K.A. 1961. Racial identification of Fraser River sockeye salmon by means of scales and its applications to salmon management. International Pacific Salmon Fisheries Commission, Bulletin 12, New Westminster, British Columbia, Canada.
- Jensen, K.A., and I.S. Frank. 1988. Stock compositions of sockeye salmon catches in Southeast Alaska's Districts 106 and 108 and in the Stikine River, 1987, estimated with scale pattern analysis. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Fishery Report 88-13. Juneau.
- Jones, J.D., and G. Thomason. 1984. U.S./Canada salmon stock interception research southern southeastern Alaska pink salmon (*Oncorhynchus gorbuscha*) tagging study, 1982. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 231. Juneau.
- Krasnowski, P.V., and M.L. Bethe. 1978. Stock separation studies of Alaskan salmon based on scale pattern analysis. Alaska Department of Fish and Game, Commercial Fisheries Division, Informational Leaflet 175. Juneau.
- Lechner, J. 1969. Identification of red salmon stocks taken in the Cape Kumlik-Aniakchak Bay fishery, Chignik area, 1967. Alaska Department of Fish and Game, Commercial Fisheries Division, Informational Leaflet 133. Juneau.
- Luenberger, D.G. 1984. Linear and nonlinear programming, second edition, Addison-Wesley, Reading.
- Major, R.L., S. Murai, and J. Lyons. 1973. Scale studies to identify Asian and western Alaskan chinook salmon. International North Pacific Fisheries, Technical Data Reports, Leaflet 75. Juneau.
- Marshall, S.L., F. Bergander, and S. Sharr. 1982. Origins of sockeye salmon (*Oncorhynchus nerka*) in the Lynn Canal drift gillnet fishery of 1981 based on scale pattern analysis. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Reports, Leaflet 75. Juneau.
- McGregor, A.J. 1985. Origins of sockeye salmon (*Oncorhynchus nerka* Walbaum) in the Taku-Snettisham drift gillnet fishery of 1983 based on scale pattern analysis. Alaska Department of Fish and Game, Commercial Fisheries Division, Informational Leaflet 246. Juneau.

LITERATURE CITED (Continued)

- Millar, R.B. 1988. Statistical methodology for estimating composition of high seas salmonid mixtures using scale analysis. FRI-UW-8806, Fisheries Research Institute, University of Washington, Seattle.
- Moles, Adam, P. Rounds, and S. Rice. Undated. Distribution of the brain parasite *Myxobolus* as a possible stock marker in sockeye salmon of Central Alaska. National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratory, Auke Bay, Alaska.
- Mosher, K.H. 1963. Racial analysis of red salmon by means of scales. Bulletin of the International North Pacific Fisheries Commission 11: 31-56.
- Rao, C.R. 1973. Linear statistical inference and its applications, second edition, John Wiley and Sons, New York.
- Sharr, S., D.R. Bernard, and W.E. Goshert. 1984. Origins of sockeye salmon (*Oncorhynchus nerka*) in the Copper River fishery of 1982 based on scale pattern analysis. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 109. Juneau.
- Tarbox, K.E., A. Moles, and D.L. Waltemyer. 1991. Presence of parasites in sockeye salmon of Upper Cook Inlet, Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2S91-5. Juneau.
- Tarbox, K.E. 1993. Kenai River sockeye salmon restoration (Restoration Science Study Number 53). Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau.
- Waltemyer, D.L., and K.E. Tarbox. 1988. Origins of sockeye salmon in the fisheries of Upper Cook Inlet, Alaska in 1986 based on scale pattern analysis. Alaska Department of Fish and Game, Commercial Fisheries Division, Technical Fishery Report 88-19. Juneau.
- Waltemyer, D.L., and K.E. Tarbox. 1991. Stock component of age-1.3 sockeye salmon returning to Upper Cook Inlet, 1987-1989. Alaska Department of Fish and Game, Commercial Fisheries Division, Technical Fishery Report 91-16. Juneau.
- Waltemyer, D.L. 1991. Abundance, age, sex and size of chinook, sockeye, coho, and chum salmon returning to Upper Cook Inlet, Alaska in 1989. Alaska Department of Fish and Game, Commercial Fisheries Division, Technical Fishery Report 91-17. Juneau.

LITERATURE CITED (Continued)

- Wood, C.C., G.T. Oliver, and D.T. Rutherford. 1988. Comparison of several biological markers used for stock identification of sockeye salmon (*Oncorhynchus nerka*) in Northern British Columbia and Southeast Alaska. Canadian Technical Report of Fisheries and Aquatic Sciences 1624, Naniamo, British Columbia.
- Wright, A.T. 1965. The use of scale circuli spacings as a means of separating races of Prince William Sound pink salmon. Alaska Department of Fish and Game, Commercial Fisheries Division, Informational Leaflet 66. Juneau.

Table 1. Sockeye salmon spawning escapement and commercial fishery samples examined for occurrence of the nematode *Philonema oncorhynchi*, Upper Cook Inlet, Alaska, in 1991.

Location	Sample Period	Sample Size	Percent Occurrence
CENTRAL DISTRICT			
<u>ESCAPEMENT</u>			
Kasilof River:			
mainstem RM 10.0	June 24-30	65	98.5
	July 8-14	50	98.0
	July 15-21	50	100.0
Kenai River:			
mainstem RM 19.5	July 8-14	50	100.0
	July 15-21	50	100.0
	July 22-28	50	100.0
Hidden Creek	August 4	18	100.0
Russian River	June 21	20	100.0
Big River:			
South Fork	July 24	50	28.0
Packers Creek:			
Packer Lake	September 10	50	14.0
Crescent River:			
mainstem RM 1.5	July 22-28	50	100.0
<u>COMMERCIAL HARVEST</u>			
Drift Fishery	July 15	300	90.7

- Continued -

Table 1. (p. 2 of 2)

Location	Sample Period	Sample Size	Percent Occurrence
NORTHERN DISTRICT			
<u>ESCAPEMENT</u>			
Fish Creek: Big Lake	July 20-29	82	0.0 ^a
Susitna River: mainstem RM 80.0	July 22-28	50	92.2
	July 29-August 4	50	77.1
Yentna River RM 5.0	July 8-14	53	58.5
	July 15-21	71	77.5
	July 22-28	50	68.6
	July 29-August 4	50	92.3
Lake Creek/Chelatna Lake	August 15-Sept. 3	50	10.0 ^b
Bishop Creek: Daniels Lake	September 12	50	2.0
Chakachatna River: Chilligan River	September 13	50	100.0
McArthur River: Creek 12.1	August 12	50	40.0

^a Represented 64 out of 65 fish infected.

^b Represented 49 out of 50 fish infected.

^c Represented only 18 fish sample taken incidental to study.

^d Represented only 20 fish sample taken incidental to study.

^e ADF&G, FRED Division personnel sampled fish during egg take operation.

^f Cook Inlet Aquaculture Association (CIAA) personnel sampled fish during egg take operation.

Table 2. Sensitivity of parasite occurrence rates for a pooled Susitna stock group to changes in relative abundance between Yentna and Susitna River sockeye salmon runs, Upper Cook Inlet, Alaska, in 1991.

Proportion of Run from		Weighted Average Estimated Prop. with Parasites *	Numbers of Sockeye	
Yentna	Susitna		With	Without
0.8	0.2	0.39	39	61
0.7	0.3	0.40	40	60
0.6	0.4	0.42	42	58
0.5	0.5	0.43	43	57
0.4	0.6	0.44	44	56
0.3	0.7	0.46	46	54
Observed Proportion Infested with Parasites				
Yentna=	0.36			
Susitna=	0.50			

* Average rate of infestation weighted by the relative run size.

Table 3. Actual contribution versus estimated mean contribution in a two-stock model for sockeye salmon stocks based on presence of parasites, Upper Cook Inlet, Alaska, in 1991.

<u>Actual Contribution</u>		<u>Estimated Mean Contribution</u>		<u>Percent Error^b</u>	
Other ^a	Susitna	Other	Susitna	Other	Susitna
1.0	0.0	1.00	0.00	-0.0%	0.0%
0.9	0.1	0.90	0.10	-0.0%	0.2%
0.8	0.2	0.79	0.21	-1.5%	6.2%
0.7	0.3	0.72	0.28	2.7%	-6.2%
0.6	0.4	0.56	0.44	-7.3%	11.0%
0.5	0.5	0.48	0.52	-4.6%	4.6%
0.4	0.6	0.36	0.64	-10.0%	6.7%
0.3	0.7	0.31	0.69	4.9%	-2.1%
0.2	0.8	0.25	0.75	25.2%	-6.3%
0.1	0.9	0.16	0.84	59.1%	-6.6%
0.0	1.0	0.07	0.93	0.0%	-7.2%

^a The stock grouping "Other" includes Kenai, Kasilof, and Crescent rivers.

^b Percent Error = (Estimated-Actual)/Actual

Table 4. Actual contribution versus estimated mean contribution for sockeye salmon stocks based on the presence of parasites. A two-stock model was used with different pooling for a Susitna drainage parasite occurrence rate.

<u>Actual Contribution</u>		<u>Estimated Mean Contribution</u>		Susitna Parasite Rates	Percent Error ^b For Susitna
Other ^a	Susitna	Other	Susitna		
0.6	0.4	0.591	0.409	0.39	2.3%
0.6	0.4	0.588	0.412	0.40	2.9%
0.6	0.4	0.586	0.414	0.42	3.4%
0.6	0.4	0.595	0.405	0.43	1.1%
0.6	0.4	0.587	0.413	0.44	3.3%
0.6	0.4	0.603	0.397	0.46	-0.8%

^a The stock grouping "Other" includes Kenai, Kasilof, and Crescent Rivers.

^b Percent Error = (Estimated-Actual)/Actual

Table 5. Proportion of Susitna drainage sockeye salmon estimated to be present when parasite occurrence rate of 0.3 is estimated with error.

Susitna River Proportion in Sample	Proportion Susitna Drainage Stock When Parasite Occurrence Rate Estimated As			
	0.50	0.40	0.20	0.10
0.0	0.00	0.00	0.00	0.00
0.1	0.14	0.12	0.09	0.08
0.2	0.28	0.23	0.18	0.16
0.3	0.42	0.35	0.26	0.23
0.4	0.56	0.47	0.35	0.31
0.5	0.70	0.58	0.44	0.39
0.6	0.84	0.70	0.53	0.47
0.7	0.98	0.82	0.61	0.54
0.8	1.12	0.93	0.70	0.62
0.9	1.26	1.05	0.79	0.70
1.0	1.40	1.17	0.88	0.78

Table 6. Proportion of Susitna drainage sockeye salmon estimated to be present when parasite occurrence rate of 0.4 is estimated with error.

Susitna River Proportion in sample	Proportion Susitna Drainage Stock When Parasite Occurrence Rate Estimated As			
	0.60	0.50	0.30	0.20
0.0	0.00	0.00	0.00	0.00
0.1	0.15	0.12	0.09	0.08
0.2	0.30	0.24	0.17	0.15
0.3	0.45	0.36	0.26	0.23
0.4	0.60	0.48	0.34	0.30
0.5	0.75	0.60	0.43	0.38
0.6	0.90	0.72	0.51	0.45
0.7	1.05	0.84	0.60	0.53
0.8	1.20	0.96	0.69	0.60
0.9	1.35	1.08	0.77	0.68
1.0	1.50	1.20	0.86	0.75

Table 7. Proportion of Susitna drainage sockeye salmon estimated to be present when parasite occurrence rate of 0.5 is estimated with error.

Susitna River Proportion in sample	Proportion Susitna Drainage Stock When Parasite Occurrence Rate Estimated As			
	0.70	0.60	0.40	0.30
0.0	0.00	0.00	0.00	0.00
0.1	0.17	0.13	0.08	0.07
0.2	0.33	0.25	0.17	0.14
0.3	0.50	0.38	0.25	0.21
0.4	0.67	0.50	0.33	0.29
0.5	0.83	0.63	0.42	0.36
0.6	1.00	0.75	0.50	0.43
0.7	1.17	0.88	0.58	0.50
0.8	1.33	1.00	0.67	0.57
0.9	1.50	1.13	0.75	0.64
1.0	1.67	1.25	0.83	0.71

Table 8. Percent error in estimating the contribution of the Susitna drainage stock to known mixtures when parasite occurrence rates were estimated from 0.2 above to 0.2 below the actual value.

Parasite Occurrence for the Susitna Stock		Percent Error* Estimating Susitna Contribution
Actual	Estimated	
0.30	0.50	40%
0.30	0.40	17%
0.30	0.20	-12%
0.30	0.10	-22%
0.40	0.60	50%
0.40	0.50	20%
0.40	0.30	-14%
0.40	0.20	-24%
0.50	0.70	67%
0.50	0.60	26%
0.50	0.40	-17%
0.50	0.30	-29%

* Percent Error = (Estimated-Actual)/Actual

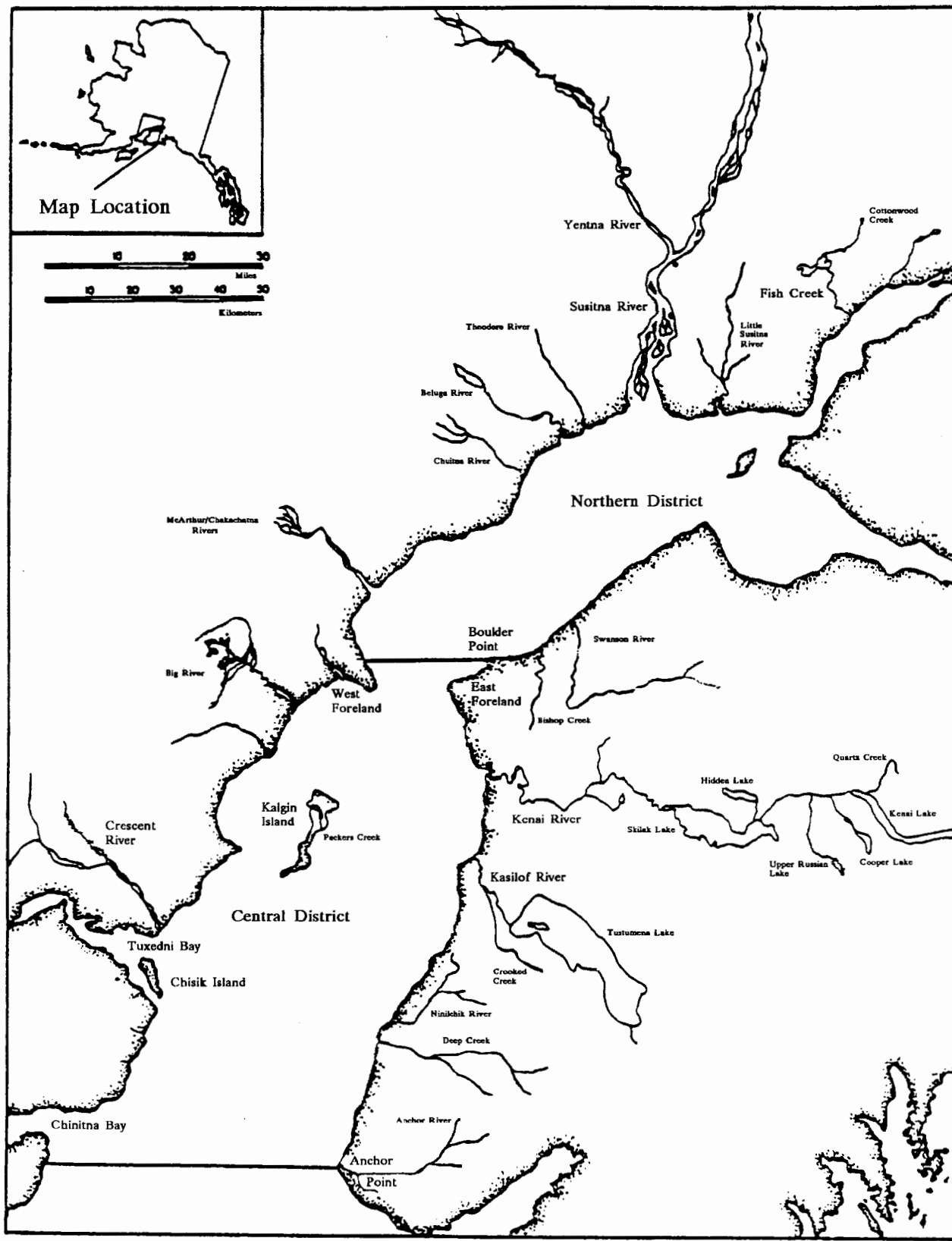


Figure 1. Map of Upper Cook Inlet showing locations of the Northern and Central Districts and the primary salmon spawning drainages.

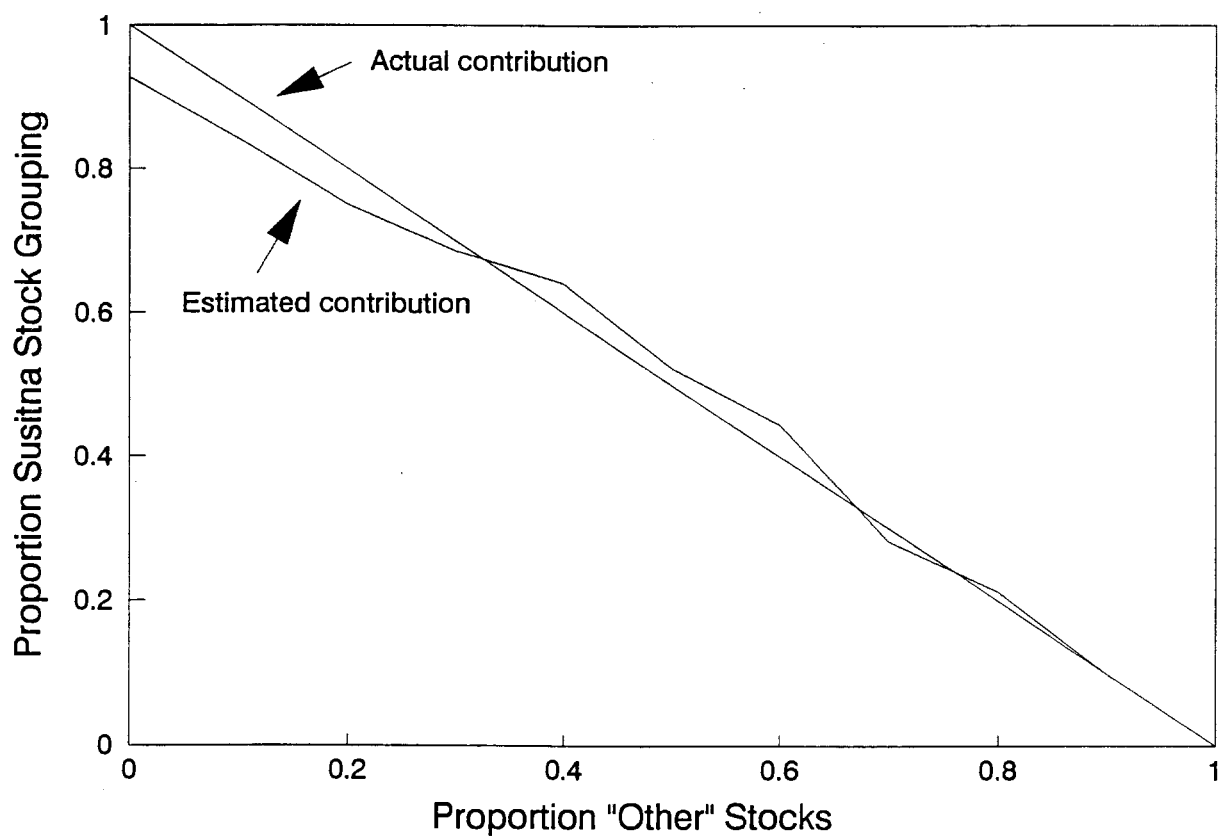


Figure 2. Proportion of Susitna versus "Other" (representing rivers with high parasite occurrence) as estimated with a two-stock model and an estimate of the pooled Susitna mainstem and Yentna River parasite occurrence rate.

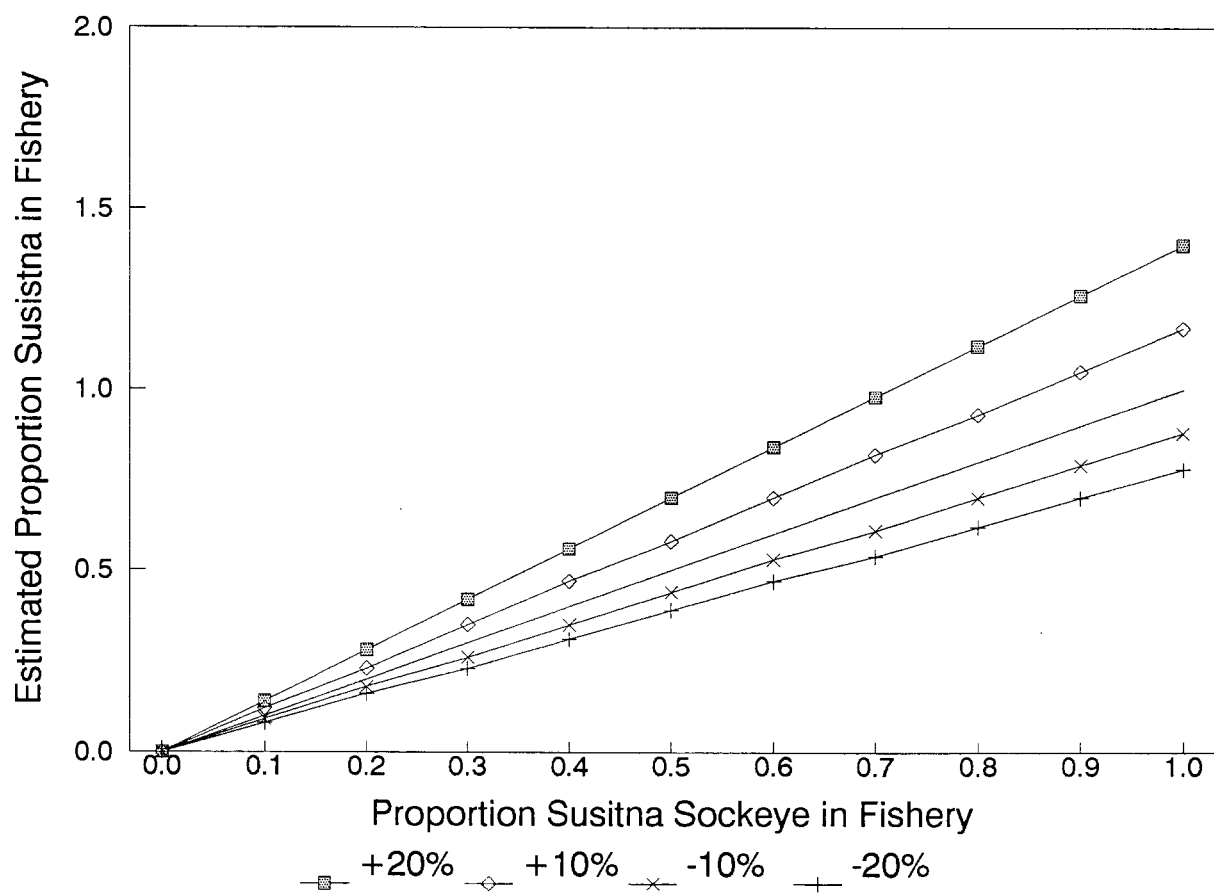


Figure 3. Proportion of Susitna fish estimated to be present in a known mixture sample when the actual parasite occurrence rate was 0.3 but was estimated at 10% intervals from 20% above (0.5) to 20% below (0.1) the actual.

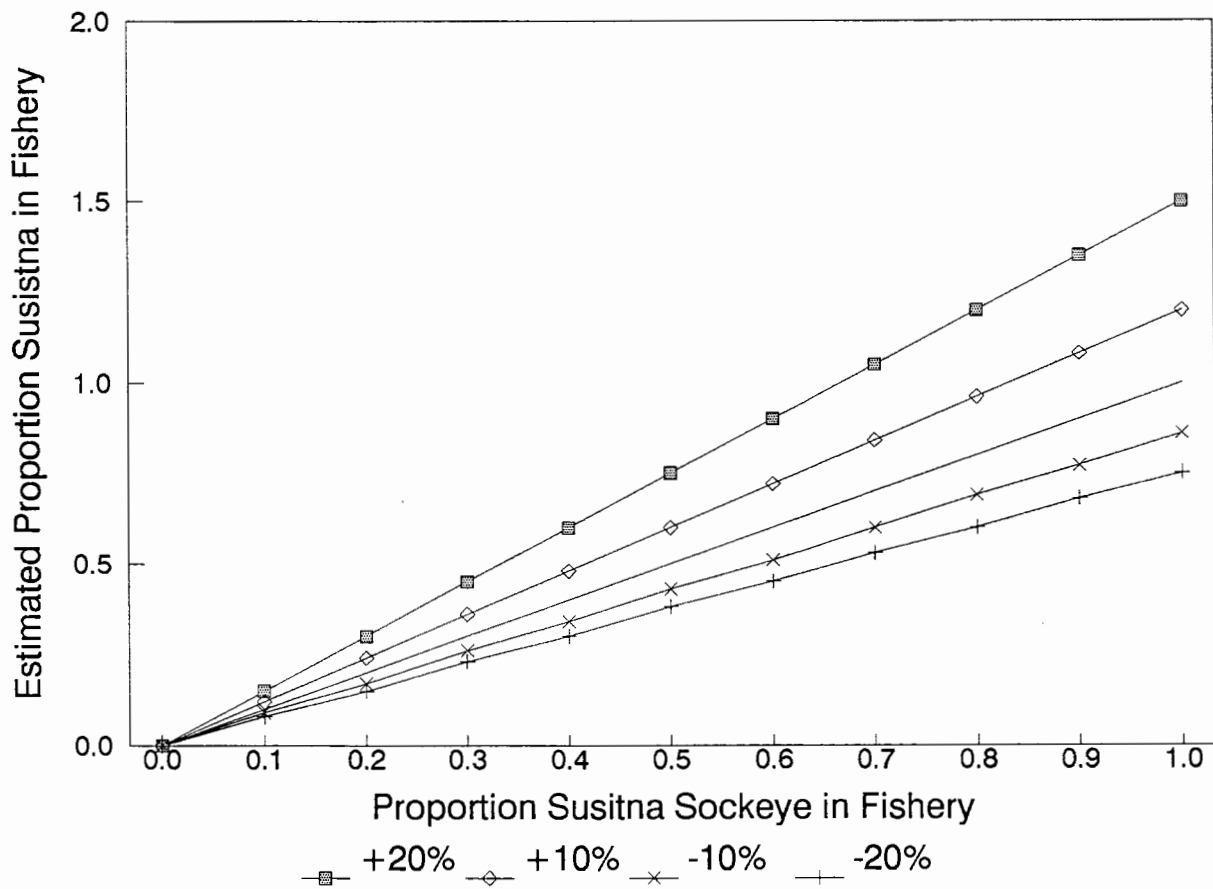


Figure 4. Proportion of Susitna fish estimated to be present in a known mixture sample when the actual parasite occurrence rate was 0.4 but was estimated at 10% intervals from 20% above (0.6) to 20% below (0.2) the actual.

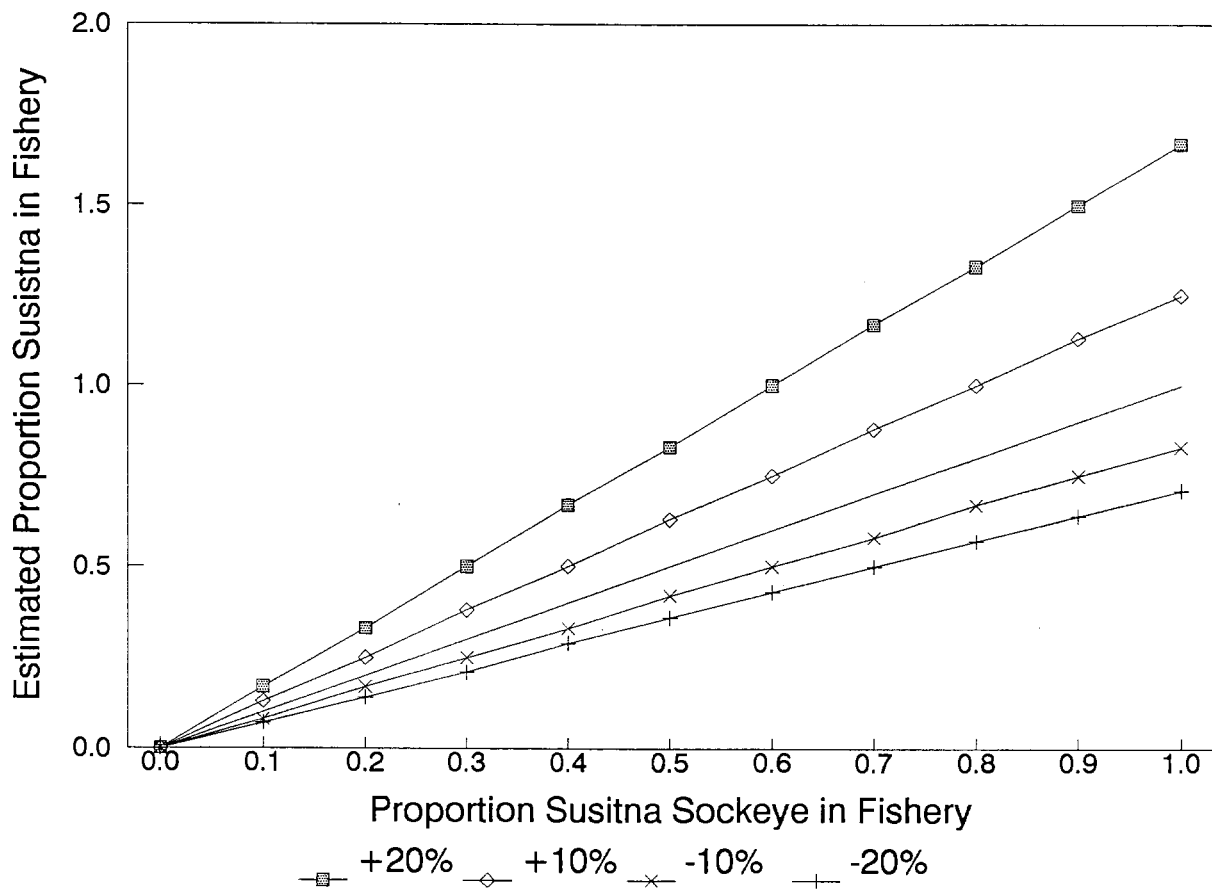


Figure 5. Proportion of Susitna fish estimated to be present in a known mixture sample when the actual parasite occurrence rate was 0.5 but was estimated at 10% intervals from 20% above (0.7) to 20% below (0.3) the actual.

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